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Enhancement of shelf life and wholesomeness of goat meat by gamma irradiation treatment

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Abstract

Goat meat is a potential source of nutrition with several health benefits. It contains lower value of saturated fats, cholesterol and high value of unsaturated fats along with B group vitamins, selenium and choline which renders it safe for the heart and reduces the risk of cardiovascular disease and cancer. Pakistan is the 4th largest producer of goat meat. Gamma irradiation processing is considered a safe and efficacious procedure for meat preservation, shelf life enhancement and microbial load reduction of fresh meat. Goat meat samples were collected from market and gamma irradiation from Cobalt 60 source (0.5, 1 and 1 kilo Gray) was applied to them in PARAS (Pakistan Radiation Services). Sensory evaluation and proximate analysis (Association of Analytical Communities AOAC protocols), before and after treatment, were done at specific intervals to determine the effects of gamma irradiation on nutritional contents and shelf life of goat meat. The present study establish that 1.5 kGy is an appropriate dosage to maintain fresh meat quality under chilled conditions for goat meat as it enhanced the refrigerated shelf life by 9 days.

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Introduction

Goat is a chordate of the family Bovidae, tribe Caprinae. (Myers *et al.*, 2006). 95% of the goats are reared in Asia and Africa making it the animal of developing countries (Haque *et al.*, 2008). The main reason for keeping goats is meat. (Casey 1992) Meat is the skeletal muscle from animals along with the connective tissue and fat naturally linked with the muscle. Edible parts can also be included. (Jeremiah 1978). The goat meat is popular in the Middle East, Africa and South Asia including Pakistan. Goat meat inventory makes up only 2% of the global meat. China leads the world goat meat production followed by India and Pakistan.

Pakistani goat meat is predominantly perceived as halal throughout the world. Pakistan's annual goat meat consumption per capita is 13.42 kilo gram (kg) while goat meat production is 270,000 tons. (Ayyub *et al.*, 2013). The production of goat meat in Pakistan in 2008 was 0.3 million MT (metric tons) where 15.4 million goats were slaughtered with 17kg meat produced by each goat. (Aziz 2010).Pakistani meat is being exported to many countries mainly Arabian countries including UAE, Kuwait, Saudi Arabia, Oman, Qatar, Bahrain and some others. In the year 2012-2013, Pakistan earned USD 151 million by exporting goat meat. (Ayyub *et al.*, 2011).

Goat meat is potential source of nutrition. It contains less saturated fats and a relatively high proportion of total unsaturated fats, which makes it an "ideal red meat" for health sensitive consumers. It contains 2.6g fat, 0.79g saturated fat, 23g protein and 63.8 mg cholesterol per 3 ounce (oz.) of cooked meat (Correa, 2011). Goat contains vitamin content where thiamine, riboflavin and niacin are present in milligram (mg), 0.1 mg, 0.56 mg, and 3.6 mg respectively. Trace elements are also present in goat meat; 100 g portion of goat muscle will be capable of providing 0.28-0.35 mg Cu, 0.059- 0.145 mg Mn and 2.79- 4.21 mg Zn. (Casey,1992). Goat meat has a low Q-6 and Q-9 polyunsaturated fat which can influence the immune system improving human health. (Gimenez *et al.*, 1985).

Goat meat protein has a digestibility coefficient of 0.97, giving ingested meat heat combustion of 17.87 kJ (kilo joules). It contains a variety of minerals i.e. potassium, calcium, magnesium, chromium, silicon, manganese, iron, nickel, zinc, cobalt, lead, sodium, copper, cobalt, molybdenum, cadmium, vanadium. The cholesterol level of goat meat is 54.4 mg/100 g. (Santos-Filho *et al.*, 2005). The proximate analysis is determination of percentage composition of main components of food i.e. protein, ash, moisture, crude fiber, fat and carbohydrate through protocols described by AOAC. (Aurand *et al.*, 1987). Goat meat, in general, contains the moisture, protein, fat, and ash contents ranging from 68% to 77%, 19% to 23%, 3.5% to 7.5%, and 1.0 to 1.5%, respectively. (Al-Bachir and Zeinou., 2014).

Meat is extremely susceptible to microbial contaminations, causing its spoilage and food borne infections in human, resulting in economic decline and health losses. (Komba *et al.*, 2012). Goat meat can transmit infections and diseases either through handling during preparation procedures or as a result of ingestion by the consumer. (Pepin *et al.*, 1997). Gamma irradiation processing of meat is recognized as a safe and effective method among the existing technologies for meat preservation. Radiation processing of fresh meat extends the shelf-life and protects the consumer against pathogenic bacteria. (Al-Bachir and Zeinou, 2009). Cobalt-60 is the most extensively employed radioisotope for gamma irradiation of food. (Stewart, 2001). The average doses reported for the goat meat are 0.5, 1, 2, 4 and 6kGy. No major sensory changes were detected in irradiated goat meat (Al-Bachir and Zeinou, 2014). Hence the present study was done to find out the optimum dose for goat meat at which there is no loss in nutritional quality and which enhanced the shelf life of goat meat.

Materials and methods

Sample collection

Goat meat sample was collected from retail markets. Meat sample was packed in Zip lock bags, labeled with specific radiation dose before irradiation.

Physical and proximate analysis was done before and after radiation treatment.

Irradiation and sample storage

The sterilization of meat was done through radiation from gamma source. A dose was optimized at which the nutrient value of the meat was least affected and no harmful microorganisms left in meat. Samples were subjected to different gamma radiations doses using cobalt 60 source at Pakistan Radiation Services (PARAS). Periodic evaluations were carried out on day 1, 3, 6, 9 and 12 days in BS General Laboratory of Lahore College for Women University Lahore.

Interval of analysis

Control and irradiated samples were evaluated at the intervals of 3 days for proximate analysis as well as shelf life evaluation was also done by placing samples in the refrigerated temperature.

Evaluation of sensory properties of goat sample

Both the control and irradiated goat meat samples were subjected to sensory evaluation periodically for 12 days using 9 point Hedonic scale. Color, texture, odor and taste of meat were determined by using this scale. Sensory evaluation (acceptability test) was carried out by 5 member untrained panel. Panelists were served a set of treated samples along with a control reference sample The test was scored on 9 point hedonic scale where 9 points to (like extremely), and 1 to (dislike extremely). This test was carried out to test the acceptance of the consumer for both irradiated and non-irradiated samples.

Proximate analysis

Determination of proximate composition was carried out in accordance with Association of official Analytical Chemists (AOAC) methods (1990). Proximate composition of a substance constitutes the different classes of nutrients present in the samples such as carbohydrates, protein, fat, crude fiber, ash and moisture as well as caloric value calculated from values of carbohydrate, fat and protein.

Determination of moisture content

For determination of moisture content, AOAC, 2005 Official method No. 934.01 was used.

The % moisture content was calculated by using following equation:

% moisture = loss in weight (g) / weight of sample * 100

Determination of Ash

For the determination of ash, AOAC, 2005 Official method No. 923.03 was used. Weight of ash was calculated by using following formula:

Weight of ash = weight of crucible + ash – weight of crucible.

The % ash content will be calculated by using following equation:

% Ash = Weight of ash/ weight of sample*100

pH determination

pH meter was used to measure the pH of goat meat.

Determination of crude Fat

For determination of crude fat, AOAC, 2005 Official method No. 922.06 was used. Loss of weight was calculated by the formula:

Loss in weight = wt. of thimbles + de-moisture sample – (weight of thimbles – fat free sample).

The % fat will be calculated by using following equation:

Fat % = loss in weight (g)/wt. of sample * 100

Determination of protein content

For protein determination, AOAC, 2005 Official method No. 991.20 was used. The basic method used for protein determination was Kjeldahl method where digestion of sample, distillation and titration were done.

% of protein was calculated by using following equations:

% protein = 0.4× titer used/ weight of sample × 6.25

Statistical analysis

By using standard error, means of different growth parameters were being compared. Results were analyzed by using Costat 6.4 program.

Results and discussion

Sensory analysis of goat meat

Sensory evaluation of meat was done according to 9 points hedonic scale (Silva, *et al.*, 2010). It was found that organoleptic properties were not much affected by irradiation. The sensory scores for control decreased from 8.6 to 2.6 within 6th days of refrigerated storage while irradiated samples ranged from 8.9 to 6.9 on the 12th day of storage. (Fig.1, Fig 2).

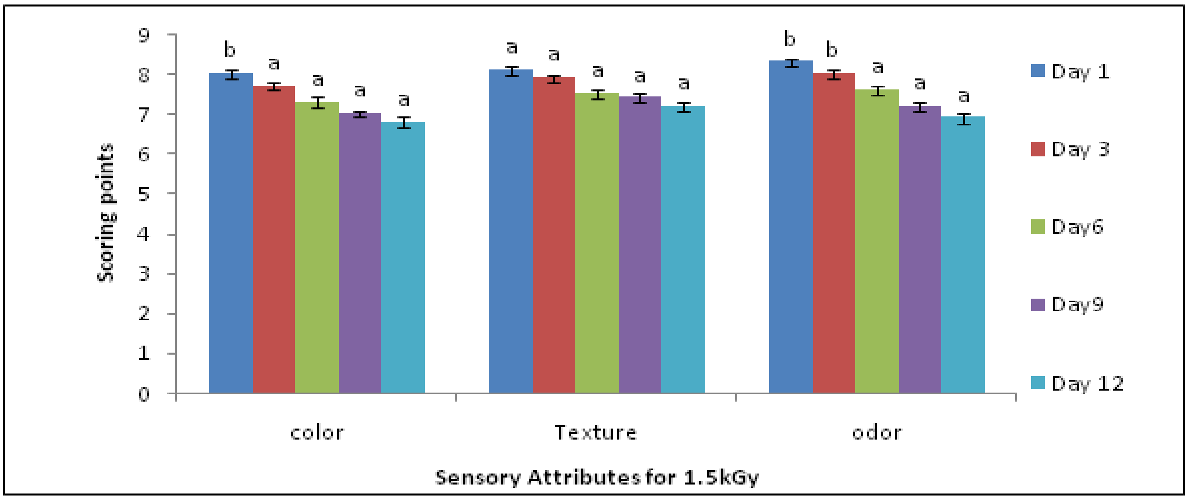

Fig. 1. Effect of gamma irradiation on sensory attributes of goat meat on respective intervals. Each value is the mean of five replicates with standard error (mean±S.D). Mean followed by different letters in the same column differ significantly at P<0.05 according to Duncan's new multiple range test.

Sensory attributes of control and irradiated samples of goat meat at different intervals					
Doses	Day 1	Day 3	Day6	Day 9	Day 12
Control				Spoilage	Spoilage
0.5 kGy					Spoilage
1 kGy					
1.5 kGy					

Fig. 2. Sensory attributes of control and irradiated samples of goat meat at different intervals.

The slight change in the color of the sample was observed by exposing to higher doses of radiation. It also highlighted the fact that the color intensity of food increases with radiation dose (Millar, *et al.*, 1995) as it was observed that the lightness and yellowness of meat increased and redness decreased at high radiation doses in contrast to the previous studies in which it was observed that redness of meat increases and lightness and yellowness decreases (Nanke, *et al.*, 1998). Color intensity is also related to the levels of myoglobin in meat which may alter by irradiation (Monk, *et al.*, 1995). Ozone, a strong oxidizing agent, is produced from oxygen during food irradiation and may oxidize myoglobin, causing a bleaching discoloration. As the storage time increased off-odor was observed.

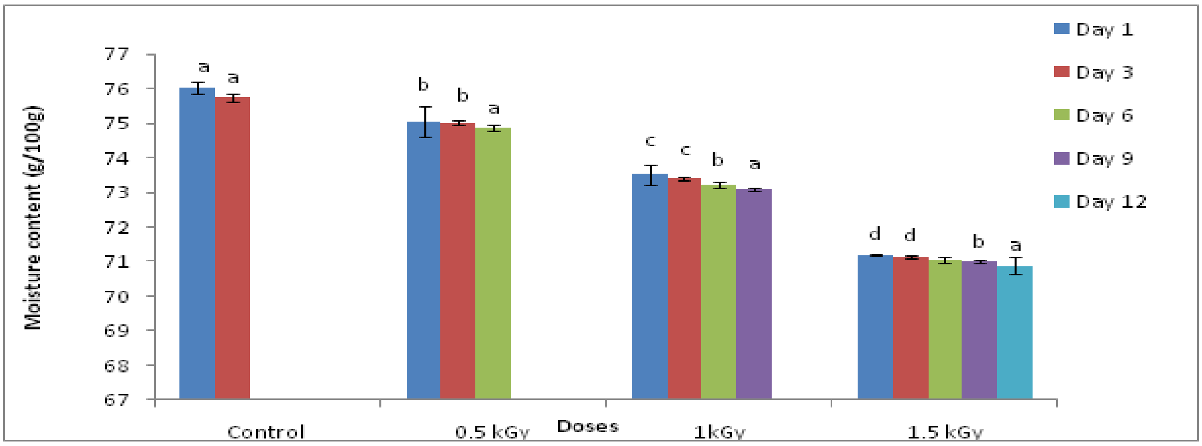

Fig. 3. Effect of gamma irradiation on moisture content at regular intervals. Each value is the mean of five replicates with standard error (mean±S.D). Mean followed by different letters in the same column differ significantly at P<0.05 according to Duncan's new multiple range test.

These results were also in agreement to the findings of (Modi, *et al.*, 2008). Off-odors are due to an accumulation of malodorous metabolic products, such as esters and thiols. Radiolytic products can also cause oxidation of myoglobin and fat, leading to discoloration and rancidity or other off-odor or off-flavor compounds (Millar, *et al.*, 1995). The storage of meat is related to its texture. The present study showed that irradiation has impact on the texture of the meat. Irradiation causes a softening of texture. Doses did not affect the texture of the meat immediate after radiation.

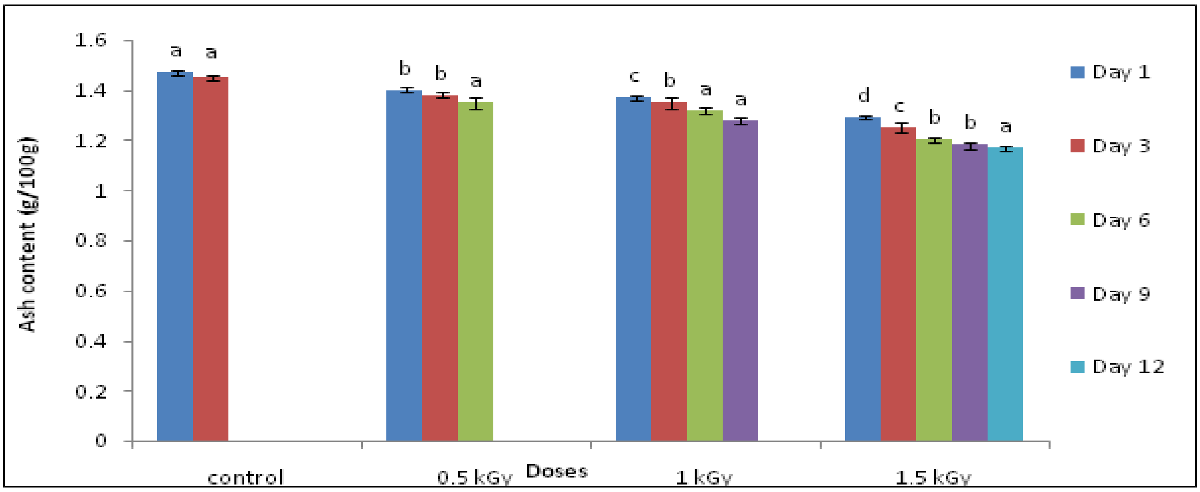

Fig. 4. Effect of gamma irradiation on ash content at regular intervals. Each value is the mean of five replicates with standard error (mean±S.D). Mean followed by different letters in the same column differ significantly at P<0.05 according to Duncan's new multiple range test.

This result was also in agreement with the findings of (Chen *et al*., 2007) who reported that radiation with higher doses caused the lowest muscle texture. The tenderizing effect of irradiation could be due to a degradation of the native collagen which rendered the connective tissue more soluble during cooking. It is generally agreed that, immediately after irradiation, meat becomes softer and tenderer during subsequent cooking. (Bailey and Rhodes, 1964).

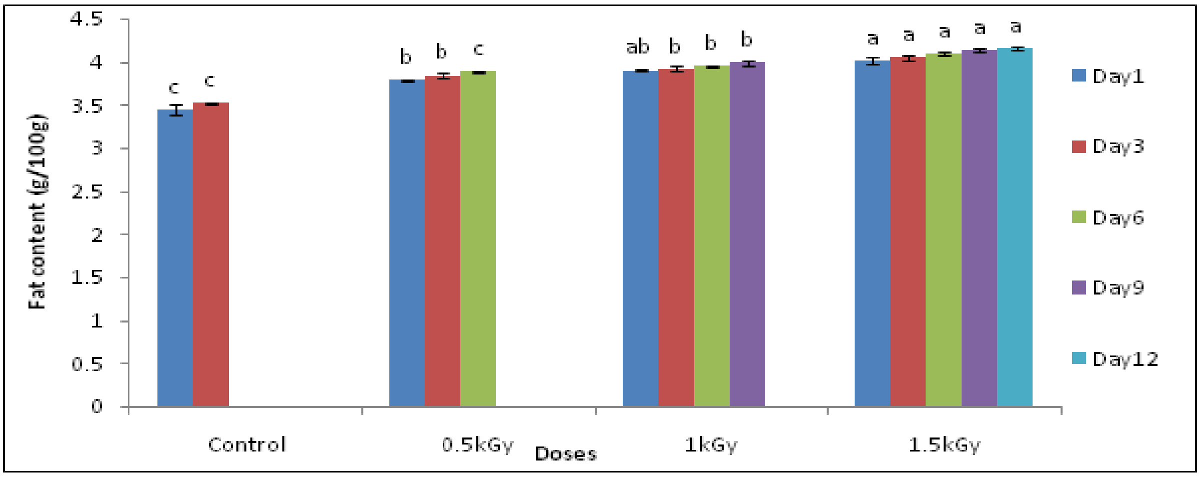

Fig. 5. Effect of gamma irradiation on fat content at regular intervals. Each value is the mean of five replicates with standard error (mean±S.D). Mean followed by different letters in the same column differ significantly at P<0.05 according to Duncan's new multiple range test.

Effect of gamma irradiation on moisture content

The moisture content of goat meat was determined for both irradiated and non-irradiated samples. The results showed that at high doses the moisture content decreased significantly, as a result of which the shelf life of meat increased for 9 days. (Fig.3) The moisture content in control sample was found near to the findings of (Islam, *et al*., 2010) and (Dhanda *et al*., 2003). The decline in the moisture content is due to reduction in metabolic activities. Moisture content also decreased with storage time. The primary reason would be evaporative loss from hot carcass as it is transferred to refrigerator. The meat irradiated at 1 kGy and 1.5 kGy also showed similar pattern for decrease in moisture content. This was in accordance with the results of (Modi, *et al*., 2008) and (Al-Bachir and Zeinou, 2014).

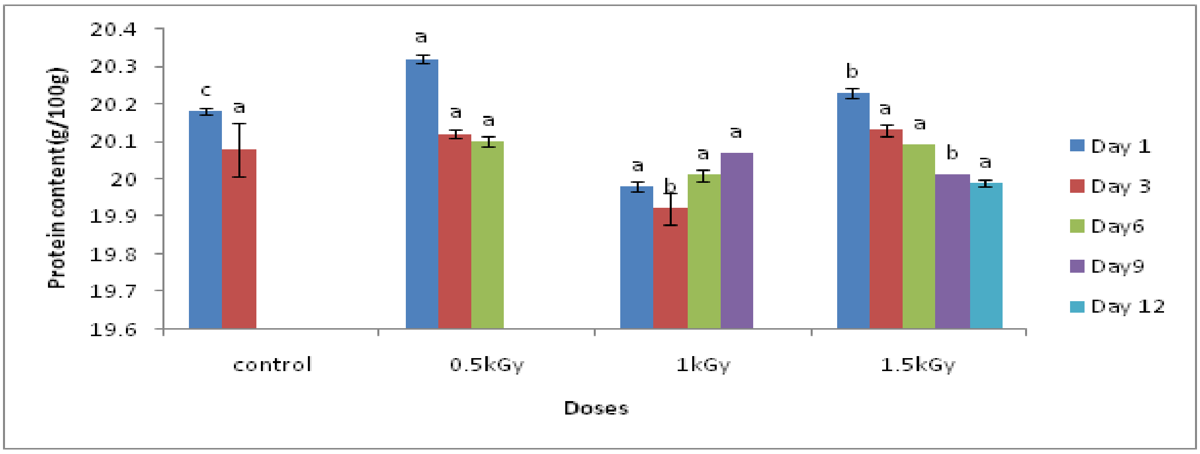

Fig. 6. Effect of gamma irradiation on protein content at regular intervals. Each value is the mean of five replicates with standard error (mean±S.D). Mean followed by different letters in the same column differ significantly at P<0.05 according to Duncan's new multiple range test.

Effect of gamma irradiation on ash content

The ash content was determined for both irradiated and non-irradiated samples at day 1, day 3, day 6, day 9 and day 12 respectively. The results showed that ash content was decreased and comparable with control sample at 1.5kGy. (Fig.4) Ash on irradiation showed a dose-dependent decrease. This study revealed the results according to the results of (Al-Bachir and Zeinou, 2014) that also demonstrated that ash content of meat decreases with increasing radiation doses.

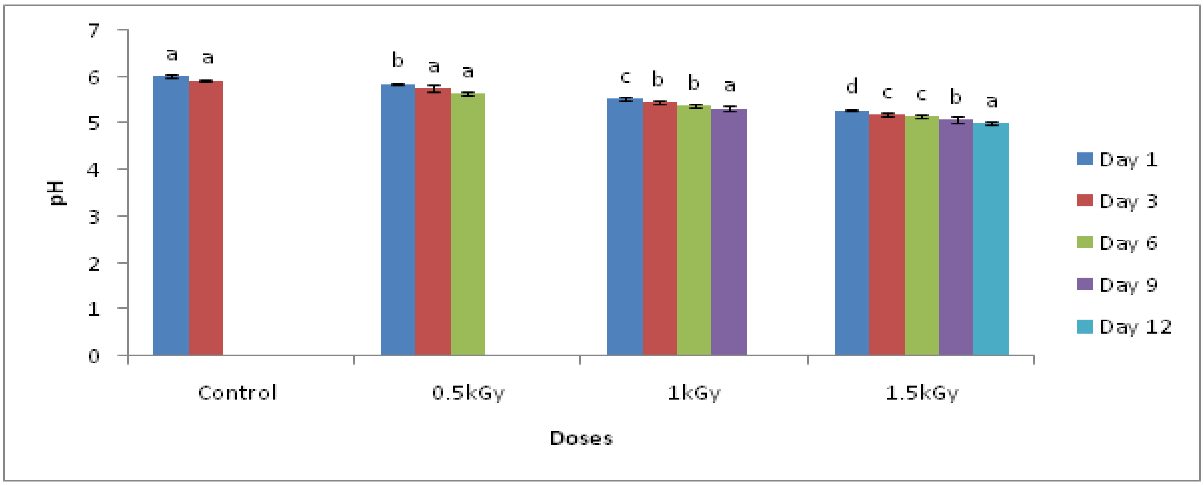

Fig. 7. Effect of gamma irradiation on pH value at regular intervals. Each value is the mean of five replicates with standard error (mean±S.D). Mean followed by different letters in the same column differ significantly at P<0.05 according to Duncan's new multiple range test.

Effect of gamma irradiation on fat content

The fat content of control sample was calculated and then compared to the irradiated ones. The results showed that the fat content increased at higher dose of 1.5 kGy as compared to 0.5 kGy. (Fig.5) The increase in fat content might be due to degradation of large lipid molecules which ultimately adds to the fat content of our sample. This trend was similar to that of (Al-Bachir and Zeinou, 2014). Water losses, occurring during irradiation, resulted in a higher dry matter content in irradiated meat than in non-irradiated control, which in turn increases the lipid content in most cases.

Effect of gamma irradiation on protein content

The Protein content was evaluated at day 1, day 3, day 6, day 9 and day 12 respectively for both non-irradiated and irradiated samples. There was no significant change in the protein content of meat and at high dose 1.5 kGy, the protein content was comparable with control sample. (Fig.6). No general trend of decrease or increase was observed in the protein content. These results were similar to that of observed by (Modi, *et al.*, 2008) and (Al-Bachir and Zeinou, 2014). This may be due to the fact that the presence of the soluble solids in meat juice may, exert a considerable effect in protecting the protein from radiation damage (Batzer and Doty, 1955).

Effect of gamma irradiation on pH value

The pH value was determined for both irradiated and non-irradiated samples at day1, day 3, day 6, day 9 and day 12. The pH value slightly decreased with increasing doses. (Fig.7) The lack of change in pH reflects that there were not enough protein breakdowns during these storage times to elicit increased pH typical of meat storage for longer periods (Modi, *et al.*, 2008). The increase in fat values in irradiated samples and during storage caused a decrease in pH values. (Morales-delaNuez, *et al.*, 2009).

Conclusion

The aim of the study was to enhance the shelf life of goat meat by gamma irradiation treatment and to evaluate the wholesomeness of goat meat after gamma irradiation treatment. The present study established that gamma irradiation treatment is a safe and efficacious procedure for goat meat preservation and it has no significant impact on the nutritional quality of goat meat. For the present study, 1.5 kGy is an appropriate dosage to maintain fresh meat quality under chilled conditions for goat meat as it enhanced the refrigerated shelf life by 9 days.

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